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SMOKE ABATEMENT SYSTEM FOR CRASH RESCUE/FIRE TRAINING FACILITIES

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This report provides the design for a smoke-abated aircraft crash/rescue trainer. The design is for a 75-ft diameter fire area suitable for operation in freezing and nonfreezing climates. With this system liquid petroleum fuels can be burned with little or no smoke by injecting a fine water spray near the surface of the burning fuel. This method of smoke abatement is being applied at military fire fighting training facilities. The report includes all equipment necessary for the smoke abatement function and provides detailed step-by-step operating procedures.

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PREFACE

This final report was prepared by the Air Force Engineering and Services Center, Tyndall Air Force Base, Florida. This research was performed under Job Order Number 2505-2003, Fire Fighter Training Smoke Abatement.

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This technical report has been reviewed and is approved for publication.

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I. INTRODUCTION

1. OBJECTIVE:

The objective of this effort was to develop a basic, cost-effective smoke abatement system for an open burning pit training facility which can be utilized at Air Force base level to train fire fighters in fire suppression.

2. BACKGROUND:

The proficiency training of Air Force fire fighters for aircraft crash/rescue work includes extinguishment exercises of large fuel spill fires that simulate an aircraft crash situation. The adequacy of most of these simulated fire/crash sites are lacking realistic affect for the training purposes. The pit area is covered with fuel, which is then ignited; the trainees are then instructed in the extinguishment of the fire and in the rescue of personnel from the aircraft.

Since aviation fuels, like J-P4, are petroleum based there will always be a huge cloud of black smoke present when it is burned. The smoke can be eliminated by injecting a fine water spray over the surface of the burning fuel. The need to provide and control this water imposes other requirements and restrictions on the training facility. This document provides the design of a smoke abated system to restrict environmentally adverse reactions to the air.

3. APPROACH:

The smoke-abatement system for an aircraft crash/rescue fire training facility was designed by engineers of two major research institutes and was revised by engineers at AFESC/RDCS Tyndall. The final design was then constructed, tested and evaluated. Any discrepancies were noted and modifications were made. The smoke-abated system was then retested and evaluated further. This technical report contains all information to acquire a cost-effective smoke-abatement system.

II. REQUIREMENTS FOR SMOKE-ABATED FIRE FACILITY

1. LOCALE

The fire facility should be located at a remote area of a base, but preferably with access to a water supply, electric power (for pumps), and adequate drainage for water disposal.

2. FIRE AREA

a. Need for Water Sublayer

A water sublayer is needed to distribute fuel uniformly over a large fire area, and to prevent the spray water from washing away the fuel. It was found effective and convenient to float the fuel atop a water sublayer.

b. Need for Crushed Stone

When a thin layer of fuel floats on water, wind forces tend to drag the fuel downwind. To reduce this effect, and to provide an area in which persons can walk, the training area is in the form of a shallow pool filled with crushed stone which protrude partially above the surface of the liquid and thus reduce the wind drag effect.

c. Need for Constant Level Control

The fuel surface must be below the surface of the crushed stone as explained in Paragraph b. The fuel cannot be allowed to penetrate deep into the crushed stone because of burning rates, flame heights, and reduction of fire severity. Deep penetration of the fuel would cause the fire to be unrealistic. A depth of about 1/2 in. is a workable fuel penetration. Since water is added to the burning area during a fire, means must be provided to maintain a constant level.

d. Need for Removing Fire-Extinguishing Agent

When the extinguishing agent is deposited on the fire during a training exercise, the foam remains in the fire area and inhibits the flame spread and rapid fire development of a subsequent exercise. To allow repetitive fires with a rapid turnaround time, the foam should be removed after each fire.

e. Need for Total Drainage

If the training facility is to be used in a region subject to freezing, the fire area must be capable of being drained to prevent freeze damage.

f. Need for Metal Covering Over Curb

A metal covering is used to prevent spalling of the concrete around the fire trainer.

3. SPRAY WATER SYSTEM

a. Water Requirements

Effective smoke abatement can be attained with a spray water deposit of 1 lb per minute per sq ft of fire area during the peak of a fire. To determine the necessary flow rate, allowance must be made for the fact that the spray from nozzles located near the periphery of the trainer extends outside the trainer.

The rate of spray water discharge during a fire is variable. For estimating water consumption, it may be assumed that the average flow during a fire is about 2/3 of the maximum flow, or 2/3 lb per minute per sq ft for the duration of a fire.

b. Spray Water Distribution

For effective smoke abatement, it is necessary to deposit the spray water on the burning fuel in a uniform manner. Experiments have shown that specified spray nozzles are effective when spaced in a square array of 8- to 9-foot centers. The nozzles are supplied from pipes beneath the surface, with the tops of the nozzles extending about 3 inches above the surface of the fuel.

c. Need for Zone Control of Spray Water

Wind affects the character of an outdoor fire, causing greater flame heights and more smoke generation on the downwind side. If the water spray were distributed uniformly over the entire training area at a rate sufficient to abate smoke on the downwind side, the flow would be excessive for the upwind side and would cause fire of insufficient severity in that region. To compensate for wind effect, it is necessary to divide the fire area into zones and to provide independent control of the spray water flow to each zone.

d. Need for Pipe Drainage

If the trainer is used in a region subject to freezing, the water piping system must be capable of being drained to prevent freeze damage.

4. FUEL SYSTEM

a. Need for Rapid Delivery of Fuel

Candidate fuels for crash/rescue trainers are gasoline or JP-4, both of which are volatile fuels. If ignition were delayed until after all the fuel is delivered, unburned hydrocarbons would be released to the atmosphere and if gasoline were used, there

could be a flammable atmosphere outside the training area. On the other hand, if ignition occurred on first fuel entry, and much time elapsed for complete delivery and distribution, the fuel consumed during this interval would be wasted. Therefore it is desirable to cause ignition on first fuel entry and to complete delivery as rapidly as practicable.

b. Fuel Distribution

If fuel were supplied through one or even several outlets, the time necessary for the fuel to spread over the entire trainer area would be excessive. Therefore the fuel is supplied through eight outlets uniformly distributed throughout the trainer area. The outlets are above the water surface and are not a hazard to personnel.

c. Aircraft Mock Up

A mock up of an aircraft in the fire area is required for training purposes. The design of the mock up is not covered in this report; however, the following recommendations are made regarding the integration of a mock up in the fire facility.

The mock-up should be located in the middle of the trainer area with the fuselage parallel to the direction of locally prevailing winds (in line with the direction from control building to fire area). From a viewpoint of smoke abatement, the entire mock-up should be supported by columns approximately 2 feet above the fuel surface. No gap should be allowed between the wings and the fuselage of the mock up. Support columns for the mock up may be placed directly on the concrete floor of the trainer if they are well-distributed and provide adequate bearing area to carry the load. The columns should be placed to offer the least amount of interference with the spray water patterns.

The life of a steel aircraft mock up could be extended by providing nozzles inside the mock up to spray water on the back of the steel plates for cooling purposes. Drain holes should be provided at the low points and adequate vents provided at the top for discharging generated steam.

III. DESIGN BASIS

The following design assumes that the trainer is located in a freezing climate and provision is made for system drainage. Storage tanks are provided for both fuel and water, to ensure the system could operate even if it were necessary to bring water by tank truck.

The design is neither the most sophisticated and costly, nor is it the cheapest. Certain requirements -- such as the size of the water storage tank or the relative orientation of the water discharge system, for example -- are site-dependent. However, it is recommended that no changes be made in the proposed design without considering all possible consequences.

IV. DESCRIPTION OF THE FIRE FACILITY AND ITS OPER'T N.

1. OVERALL LAYOUT OF THE FIRE FACILITY (SEE FIGURE 6)

The fire area is a 75-feet diameter circle surrounded by a short curb and a 5-foot-wide apron extending around the periphery beyond the curb (see Figure 1). This circular area should contain a bed of crushed stone, a layer of water, and piping systems for the distribution of fuel and spray water as described below. A concrete tank containing a weir assembly of constant level control is located immediately outside the curb of the fire area.

A control building is located 187 feet from the curb of the fire area, in a direction to asure that local prevailing winds will be from behind the building towards the trainer. From this building, an operator will control manually the rate of spray water discharged in the 5 zones of the trainer during a fire. The floor of the control building is elevated 10 feet above ground to provide the operator with good visibility of the fire area.

2. FUEL SYSTEM

a. Storage Tank and Pump

The fuel storage tank is located above ground with a dike built around it. The tank is located 200 feet from the smoke abatement facility. The tank will be refueled periodically from a tanker truck. The fuel level in the tank is to be determined by a dip stick.

A layout of the fuel tank and associated piping is shown in Figures 2 and 6. A centrifugal pump is driven by a directly-coupled electric motor located on a pad at floor level, inside the fuel pump house. Fuel flows by gravity from tank to pump and is pumped through the fuel piping system to the smoke abatement facility (Figures 2 & 3). The fuel pump, a 3 H.P. electric motor fuel meter, a fuel manifold, and all valves and explosive-proof electrical fixtures are located in the fuel pump house.

A strainer is in the pump discharge line upstream of the valves and fuel meter. (The strainer may be omitted if the fuel meter does not require protection)

b. Fuel Metering and Control

The supply of fuel to the trainer is controlled by a manually operated gate-type valve located in the fuel control building.

A fuel meter to indicate total flow (not rate of flow) is located near the supply valve in the control building. The operator would open the supply valve just long enough to deliver

the desired amount of fuel. Therefore the amount of fuel delivered must be clearly visible on the meter; or else the meter must provide a signal when a preset specified amount has been delivered.

c. Fuel Piping (Figure 2)

The fuel pump and piping system are sized to deliver 200 gallons to the burn area in 30 seconds or less. It is estimated that this amount will provide for a preburn of 30 seconds to achieve a well-developed fire, plus at least 2 minutes for the extinguishment exercise.

After leaving the control building, downstream of the supply valve and meter, the fuel supply is divided into five parallel pipes leading to the trainer area (Figure 2). There they feed branch pipes leading to individual fuel outlets. The parallel supply pipes are joined at the far end of the fire area to equalize pressure in the system.

The fuel pipes are below the grade and are pitched over their entire length so they can drain naturally into the smoke abatement facility.

d. Fuel Outlets (Figure 2)

Eight fuel outlets in the trainer area are spaced in a square array on 9-foot centers. Each outlet consists of an inverted U-shaped assembly. The inverted U serves as a trap to prevent the entry of water into the fuel system. Fuel is discharged into the trainer, as a horizontal stream, from nozzles (side outlet cross) located below the water surface as shown in Figure 3.

e. Means of Ignition (Figure 4)

Four Ignition Transformers 120/10,000 Vac furnish power to four champion heavy duty Gas Turbine Type spark plugs, this system has proven successful under all conditions.

The ignition takes place when the wave of flowing fuel reaches the spark gap. The electrical devices include a push button momentary contact switch, and an ammeter in the primary of the transformer that indicates secondary currents, which are the same for spark or shorted gaps.

The igniters are mounted on a cast aluminum fuze box. Four igniters are designed for the system. The igniters are positioned to 1 inch above the water surface (only 1 inch of the igniter is above the surface; everything else is below). The high voltage leads attach to the center electrode and the conduit body serves as a ground. All connections must be water proof.

Four transformers are used - one for each spark plug - while the primaries are activated simultaneously. Care must be taken in

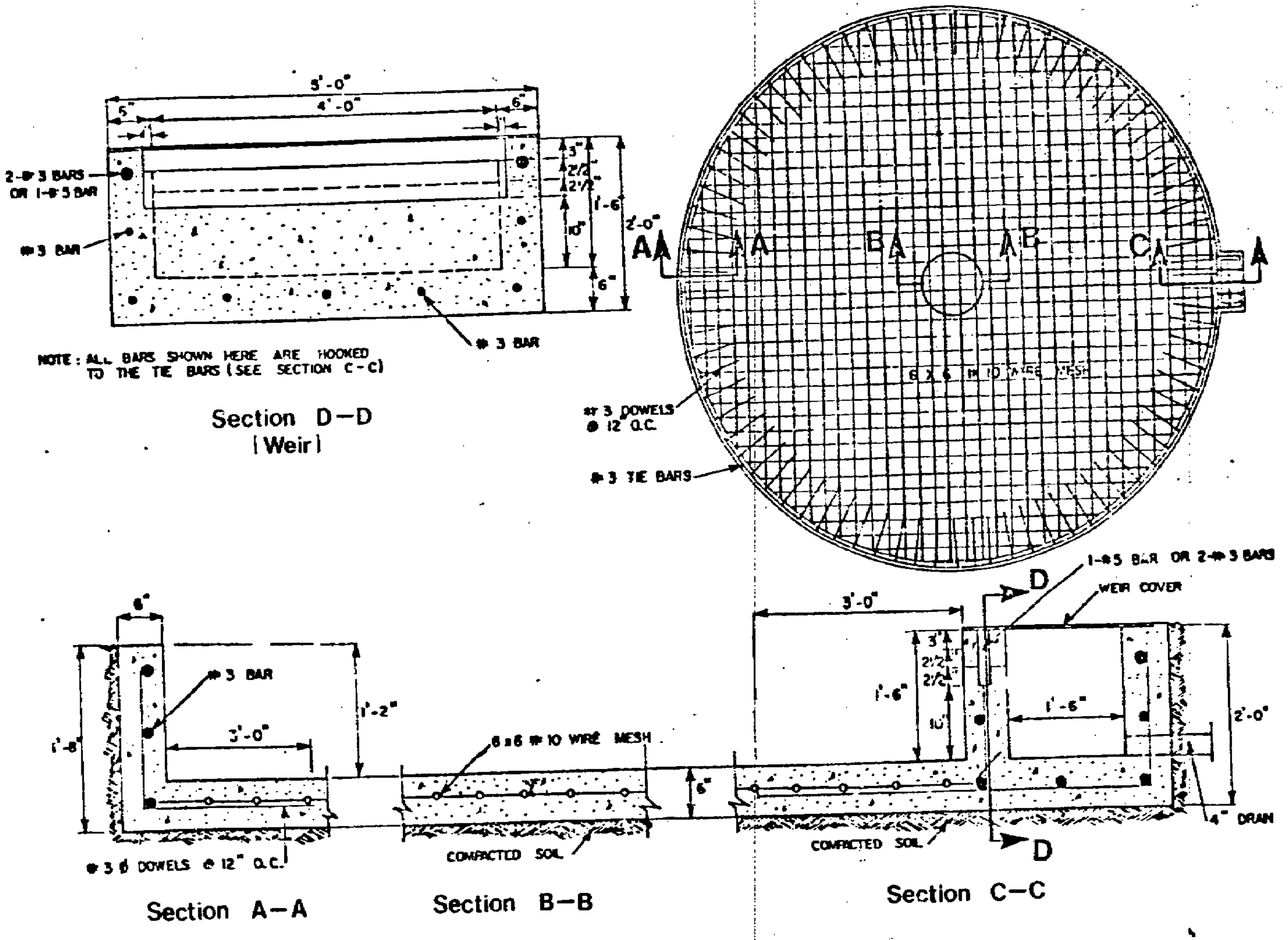
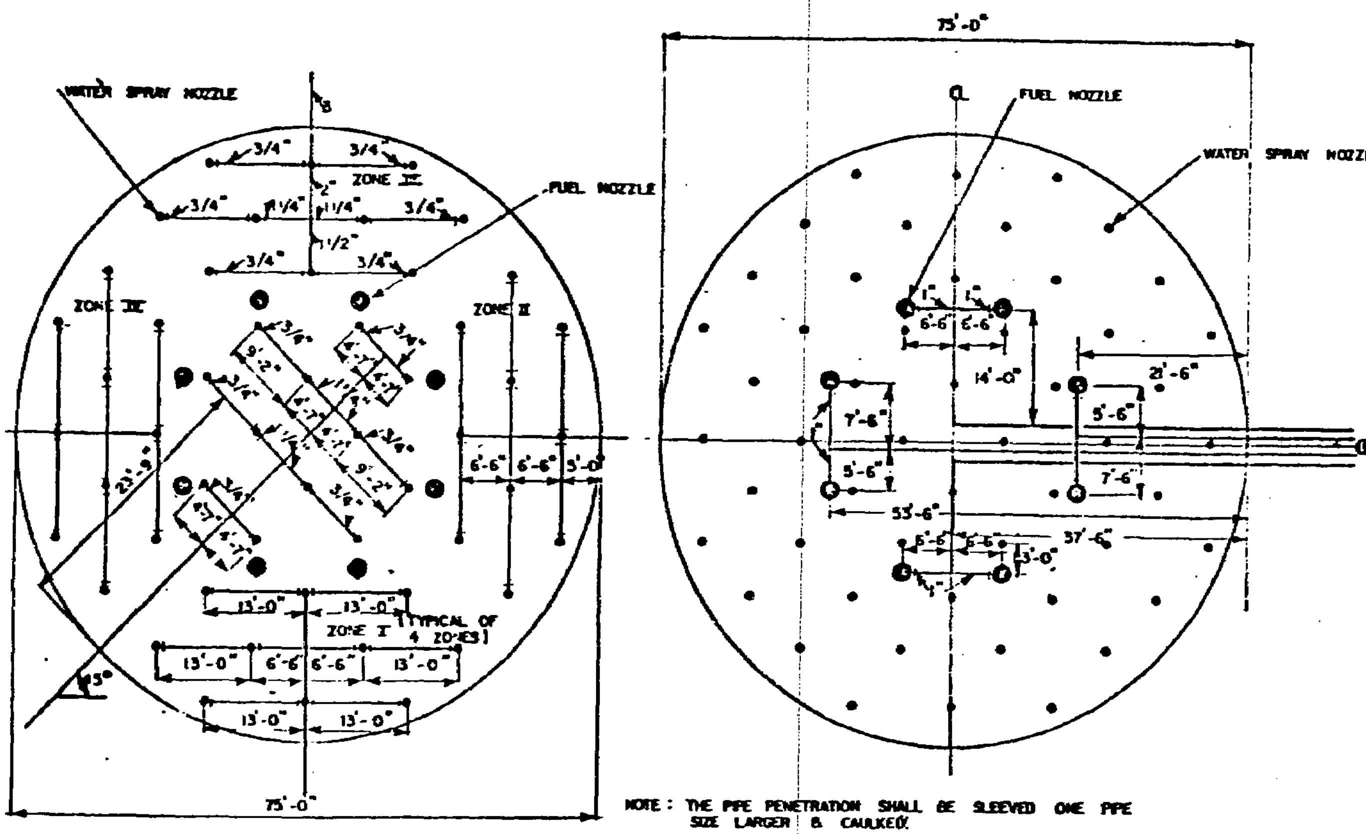


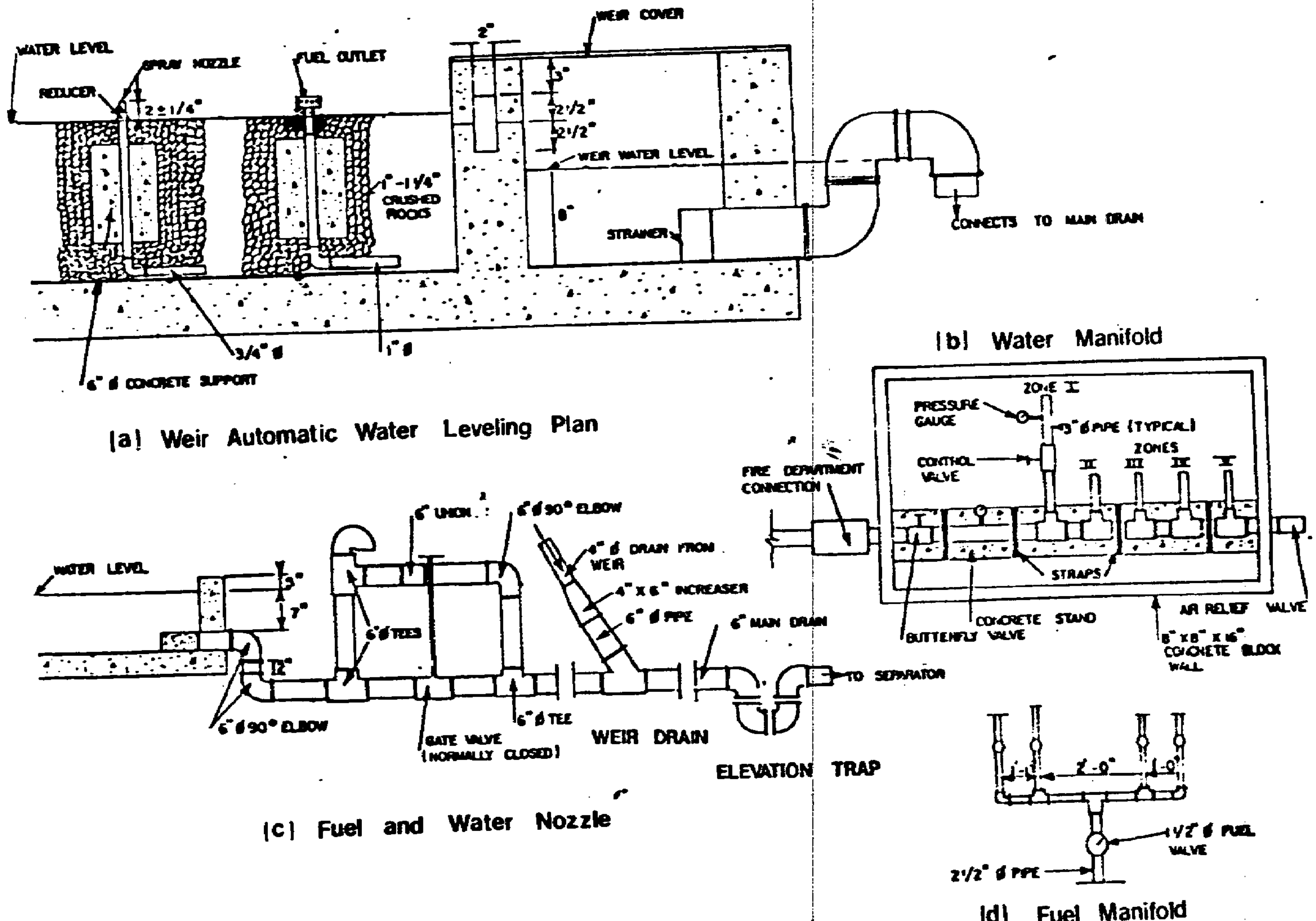
Figure 1. Smoke Abatement Concrete Reinforcement Plan



(a) Water Piping Plan

(b) Fuel Piping Plan

Figure 2. Water and Fuel Piping Plan



(a) Weir Automatic Water Leveling Plan

(b) Water Manifold

(c) Fuel and Water Nozzle

(d) Fuel Manifold

Figure 3. Water Leveling Plan, Water and Fuel Manifold, Fuel and Water Nozzle Diagrams

wiring the primaries in parallel so that an auto transformer effect is not produced. The transformer operates with a primary current that fluctuates between .15 amps with an open secondary to 1.7 amps with a closed or sparking secondary.

Because of the large difference between open and closed circuit current for the transformer, an ampmeter may be used in the primary circuit to indicate when the plugs are properly firing. Note that primary current is the same whether the plugs are burning or shorted. Note also that increasing the length of the igniter lead wire produces a stronger arc at the plug tip.

WARNING

Since the transformers are mounted in a metal casing and the secondary is midpoint grounded, it is possible to develop 5000 volts between equipment ground and any one of the electrodes on the transformer. To eliminate this possible shock hazard, isolate the transformer mounts from ground.

A good solid connection must be made to the center electrode of the igniter; if connections are loose there will be back arcing in the igniter body. This condition is undesirable because the spark does not occur on the tip and is unsafe because the insulation of the igniter leads will burn.

3. WATER SUPPLY SYSTEM

a. Storage Tank and Pumper

In the design of the water supply it is assumed that there is no access to a water main and that water must be brought in by tanker truck. If a water source is available locally, the size of the storage tank could be reduced after due consideration of the rates of usage and the available water supply.

The water storage tank is located below ground near the control building. A layout of the tank and associated piping is shown in Figures 2 and 6. For these drawings it is assumed that a water supply that can deliver water at a low rate is available, so the water level in the storage tank is controlled by a float valve. The tank is supplied by a well and a 3 HP submersible pump.

A Fire Department pumper drafts water from the storage tank to the Fire Department connection on the control building where the flow is divided into five separate controlled paths leading to the different zones in the smoke abatement facility.

b. Control of Spray Water Supply

The rate of spray water delivery and its distribution over the trainer area are controlled manually by five valves located in the

control building. During a fire exercise, an operator adjusts these valves, in response to his visual observation of the fire, to limit smoke generation and yet maintain a realistic fire.

The Fire Department pumper controls the flow to a manifold or header feeding five separate pipes leading to the different zones in the trainer (Figure 3). Each of the five zone pipes contains a similar control valve used to regulate the rate of spray water delivered to the individual zones in the trainer.

c. Water Supply Piping

The water supply system is designed to provide a spray water rate of 1 lb per min per sq ft of fire area with a margin of safety. To maintain the safety margin, the pressure loss in the piping system from the pump to the spray nozzles should not exceed 20 psi.

Downstream of the zone control valves, the water supply pipes run below grade to the individual zones in the trainer area (Figure 2), entering at four different locations within the trainer. The water supply pipes to the water spray nozzles are Schedule 40 pvc. Black iron pipe is used eighteen inches back where pipe and nozzle penetrate the water and rocks.

d. Zone Layout

The distribution of spray water within the trainer area is divided into five zones, with the flow to each zone independently controlled by the operator in the control building. The layout of the zones is shown in Figure 2. Zone No. 1 covers a large central area in the trainer, while the other four zones are symmetrically spaced around the periphery. The water spray nozzles are uniformly arranged in a square array on 9-feet centers.

The piping arrangement for each of the five zones is shown separately on Figures 2 and 3. These figures also show a detail of the riser and spray nozzle combination, and their relative elevations. The riser pipe to the nozzle must be plumb; otherwise the spray from a nozzle will not be horizontal and will not cover the intended fire area. Specified spray nozzles are commercially available.

4. LEVEL CONTROL AND DRAIN SYSTEM

Water in the trainer area is maintained at a constant level by a passive system consisting of a weir-type overflow arrangment. The water level can be held constant within a fraction of an inch regardless of variations in the rate of water inflow from the spray nozzles or the extinguishing agents.

a. Trainer Area

To facilitate the outflow of water from the trainer area without suffering excessive head loss caused by the bed of stones, the smoke abatement facility is built to slope 4 inches, on the 75 foot diameter fire pit, towards the weir.

The flow resistance of the bed of crushed stone can be kept low by using relatively large stones of uniform size. It is recommended that the crushed stone consist of gap-graded aggregate with 100 percent passing a 3-inch sieve and zero percent passing a 2-inch sieve (or as close to zero as can be obtained commercially).

b. Weir Assembly

The weir assembly for constant water level control is controlled by means of 6-inch piping, tees, 90° elbows, and a constant leveling device installed approximately 150 feet to the rear of the weir. The piping assembly is pvc Schedule 40, which in turn drains into the Separator. See Figure 3.

c. Draining of Trainer

Provision is made for draining the entire fire facility, including the weir tank, through a manual gate valve located at the rear of the weir tank (Figure 3). In a freezing climate, it would be necessary to open this valve at the end of each day's use.

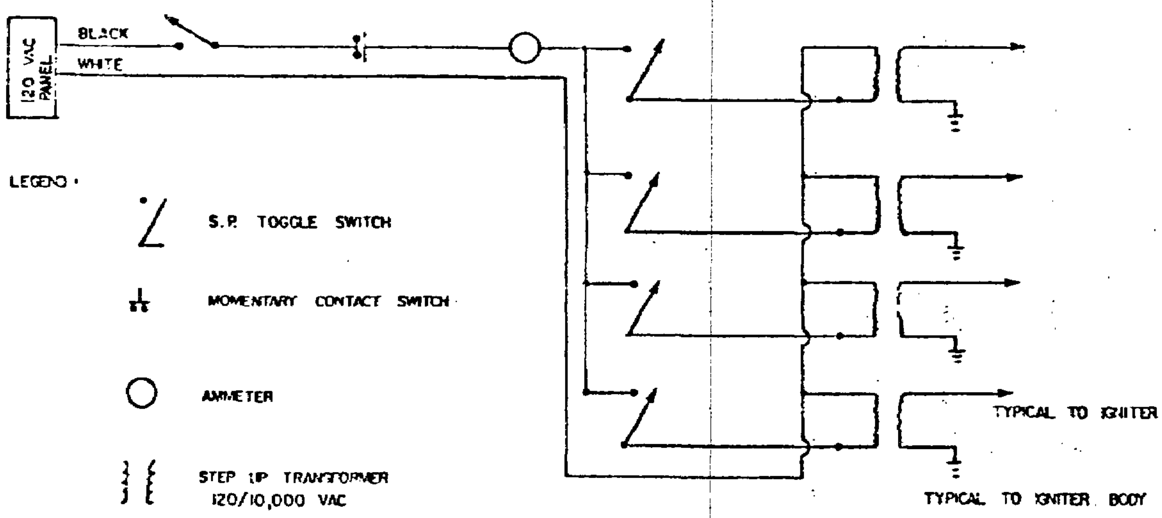
5. FOAM SKIMMING SYSTEM

Extinguishing foam that remains floating in the fire area after an exercise can be removed easily by adding water until it overflows the curb surrounding the fire area.

Removal of foam can be accomplished by using the water exit from the trainer through the smoke abatement drain system. See Figure 3.

The weir system is an automatic leveling system. Water is added to the Trainer by opening all water control valves until the trainer is full. Once full, the spray nozzles discharging at maximum flow aid to flush the foam over the curb. The overflow from the trainer which consists of foam, unburned fuel, and water, flows under gravity into the drain, to the separator.

The separator is a series of concrete lagoons, (see Figure 5) which allows the fuel to evaporate into the atmosphere. The aqueous film forming foam is biodegradable and along with the water, passes through the lagoon into the drain field.



NOTES:
1. ONE TRANSFORMER FIRES ONE IGNITER.
2. A SEPARATE LEAD WIRE IS REQUIRED FOR EACH.
3. IGNITER BODIES CAN BE BONDED TOGETHER OR CONNECTED SEPARATELY.

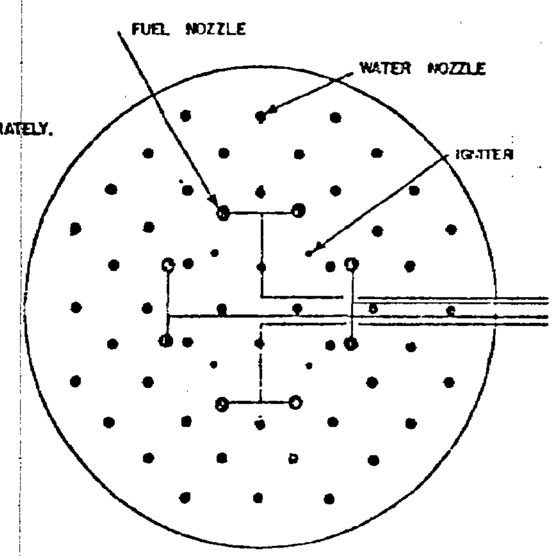


Figure 4. Electrically Operated Fuel Igniters

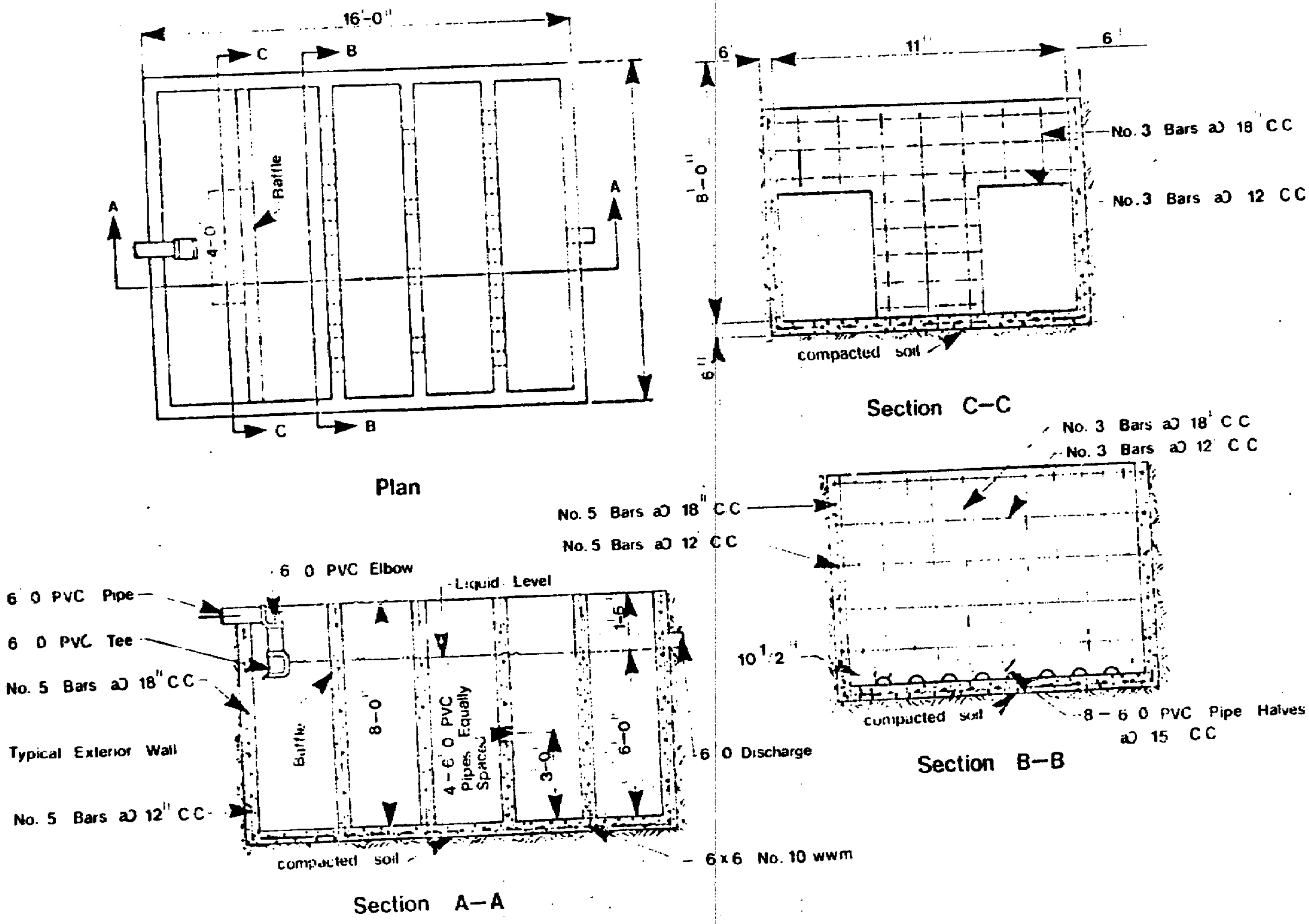


Figure 5. Water and Fuel Separator

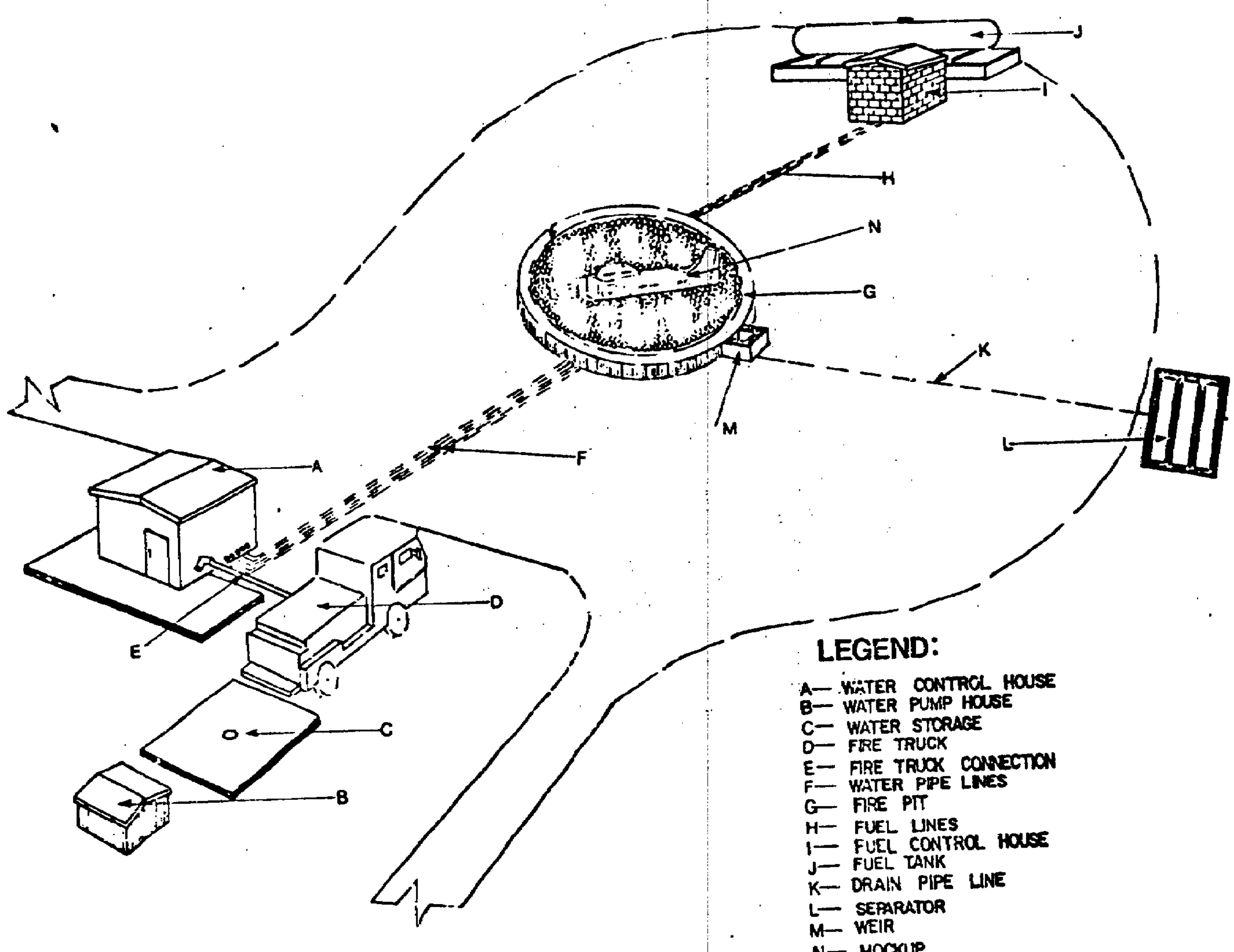


Figure 6. Site Plan

V. PERFORMANCE REQUIREMENTS OF MAJOR EQUIPMENT ITEMS

The performance requirements of major items of equipment in the water and fuel systems are listed in the following paragraphs. Items not specifically identified should be commercial grades suitable for use with water or petroleum fuels as applicable.

1. WATER SYSTEM

Water used for the smoke abatement system is untreated tap water.

a. Water Piping

All piping is standard weight (Schedule 40) pipe, and Schedule 40 iron pipe.

b. Float Valve

Nominal 100 psi globe or angle valve; brass; screwed. Float up to close. Size to fit water supply line.

c. Pump

Three HP submersible pump installed in well to supply reservoir.

d. Fire Department pumper will pump from reservoir to Fire Department connection. See Figures 3 & 6.

e. Fire Department connection for supplying the 5 control valves.

Control valves for zones 1,2,3,4,5: 100 gpm each; size 3 in.

f. Water Spray Nozzles

The spray nozzles are identified as follows:

(1) Extra Wide 180° spray angle, series TFXW

(2) Nozzle Number: TF12XW

(3) Material: Brass

(4) Manufacturer: Bete Fog Nozzle, Inc.
305 Wells St.
Greenfield, Mass 01301

g. Drain Valves (5)

Nominal 100 psi gate valve; brass; screwed. Size: 2 #1 inch; for below ground installation with extended handles.

2. FUEL SYSTEM

All components of the fuel supply system must be compatible with liquid petroleum fuels such as gasoline or jet fuels.

a. Piping

All piping is standard weight (Schedule 40) pipe, wrapped and coated for corrosion protection.

b. Pump

Fuel pump suitable for JP-4 fuel, bronzed, fitted size S-2X 2-1/2 x 10 from Aurora pumps, model II 411 BF, 3 HP explosion proof, 1750 RPM, 230/460 volts 60 cy 3 phase pump capacity. 200 GPM at 35 head w/right hand rotation controlled by a size "0" magnetic starter with push button station in cover.

c. Fuel Control Valve

Manually operated gate-type valve to pass 200 gpm with pressure loss not to exceed 2 psi.

d. Fuel Meter

Meter to indicate total fuel delivery in gal; flow rate to 300 gpm minimum; nominal line pressure of 100 psi. Register resettable to zero after each use, with alarm or visual indication at conclusion of flow. Caution: meter should be filled with fuel prior to full opening of fuel control valve.

e. Drain Valve

Nominal 100 psi gate valve; brass; screwed. Size: 1 in.; for below ground installation with extended handle.

f. Ignition System

(1) Ignition transformer 120/10,000 vac 4 each.

(2) Fuel igniters champion heavy duty Gas Turbine Type STK No. 2925002936481 (FS47-11).

(3) High Voltage cable used 14 gauge at 15,000 volts.

VI. OPERATING PROCEDURE - FREEZING ENVIRONMENT

1. STEADY STATE CONDITION DURING PERIOD OF IDLENESS

   a. No water in trainer.

   b. No water in water piping system.

   c. No fuel in fuel piping system.

   d. Main water control valve and all zone control valves are open.

   e. Water piping drain valves are open.

   f. Fuel piping drain valve is open.

   g. Drain valve from weir tank is open.

   h. Water supply valve to storage tank is closed.

   i. Fuel supply valve is open.

2. FIRST BURN

   a. Open water supply valve to storage tank.

   b. Check operation of float valve and water level in water storage tank.

   c. Close water piping drain valves.

   d. Close fuel piping drain valve.

   e. Close fuel supply valve.

   f. Close drain valve from weir tank.

   g. Start fuel pump.

   h. Open fuel supply valve and fill fuel piping system until fuel just begins to enter trainer.

      Note: Amount of fuel required to fill piping system is to be determined during construction and will be a constant for the facility.

      <u>CAUTION</u>: Fuel meter must be filled slowly before the fuel valve is completely opened.

   i. Close fuel supply valve.

j. Shut off fuel pump.

k. Start water pump. Draft with Fire Department pumper.

l. Open discharge gates on pumper and all five zone valves.

<u>CAUTION</u>: Open discharge gates on pumper only after fuel piping system has been filled with fuel. See Step 2(h).

m. Fill trainer with water.

n. Set zone valves to desired opening.

o. Reset fuel meter.

p. Ignite spark plugs.

q. Start fuel pump.

r. Open fuel supply valve and deliver desired amount of fuel.

<u>CAUTION</u>: Fuel meter must be filled slowly before the fuel valve is completely opened.

s. Close fuel supply valve.

t. Shut off fuel pump.

u. Control spray water during burn.

v. After burn, close discharge gates on pumper.

3. SECOND AND SUBSEQUENT BURNS

a. Open discharge gates on pumper and five zone valves.

b. Fill trainer until foam and fuel overflow curb.

c. Use water hose if necessary to flush foam over curb.

d. Close discharge gates on pumper.

e. Repeat steps 2(n) to 2(u).

4. SHUTDOWN AFTER LAST BURN

a. Repeat steps 3(a) to 3(d).

b. Open drain valve from weir tank.

c. Open all zone control valves.

d. Open water piping drain valves.

e. Open fuel drain valve.

<u>CAUTION</u>: Open fuel drain valve only <u>after</u> water has drained.

f. Open fuel supply valve.

VII. OPERATING PROCEDURE - NONFREEZING ENVIRONMENT

1. STEADY STATE CONDITIONS DURING PERIOD OF IDLENESS

   a. Water piping drain valves are closed.

   b. Fuel piping drain valve is closed.

   c. Drain valve from weir tank is closed.

   d. Fuel supply valve is closed.

   e. Trainer contains water to some arbitrary level depending on evaporation loss.

2. FIRST BURN

   a. Check operation of float valve and water level in tank.

   b. Draft with Fire Department pumper from reservoir.

   c. Open discharge gates and five zone valves.

   d. Fill trainer with water.

   e. Set zone valves to desired opening.

   f. Reset fuel meter.

   g. Ignite spark plugs in trainer.

   h. Start fuel pump.

   i. Open fuel supply valve and deliver desired amount of fuel.

      <u>CAUTION</u>: Fuel meter must be filled slowly before valve is completely opened.

   j. Close fuel supply valve.

   k. Shut off fuel pump.

   l. Control spray water during burn.

   m. After burn, close discharge valves on pumper.

3. SECOND AND SUBSEQUENT BURNS

   a. Open discharge gates on pumper and five zone valves.

   b. Fill trainer until foam and fuel overflow curb.

c. Use water hose if necessary to flush foam over curb.

d. Close discharge gates on pumper.

e. Repeat steps 2(m) to 2 (u).

4. SHUTDOWN AFTER LAST BURN

a. Repeat steps 3(a) to 3(d).

VIII. CONCLUSIONS

An examination of the results of the technical test and evaluation program leads to the following conclusions:

1. Substantial cost savings can be achieved using this design to train crash rescue fire fighting crews.

2. During all testing of the design the system removed 90-95 percent of the visible smoke. The resulting smoke density was less than 60 percent of the maximum density set by the Federal Clean Air Act.

3. Satisfactory training of fire fighters in the art of aircraft ground fire suppression and rescue can be achieved with this system.

4. This design is a basic, cost-effective training facility, that can be constructed at base level to train fire fighters in fire suppression utilizing aqueous film forming foam (AFFF).

5. The facility does not provide realistic training for the AS 32/P-13 crash rescue vehicle, in that back-flash potential negates the effective use of this vehicle's agents. This is due primarily to the heated rocks within the pit

APPENDIX A

Estimate of Construction Costs
for Smoke Abated Fire Facility

1. BASIS FOR COST ESTIMATE

An estimate was made of the costs for constructing a smoke-abated fire facility as described in Sections IV and V and as illustrated in Figures 1 thru 6 of this report. The costs are based on all labor accomplished in house. The costs are considered realistic for the design as described.

2. BREAKDOWN OF COSTS

a. Excavation Work - - - - - - - - - - - - - - - - - - - $ 4,000

(1) Grade ground material to depth indicated on drawings.

(2) Do necessary machine and hand excavation for various trenches.

(3) Install and compact 8-in thick bed of sand or gravel as base for concrete slabs and footings.

(4) Fill Fire area with 2-1/2 in size crushed stone.

Note: Excavation depth is based on approximately 3,000 lb per sq ft soil bearing conditions.

b. Concrete and Related Work - - - - - - - - - - - - $ 8,000

(1) Install 8-in. thick reinforced concrete slab over entire trainer area. Slab to be reinforced (for temperature effects) with No. 4 steel bars on 1-ft centers in each direction.

(2) Install concrete curb to enclose fire area.

(3) Install concrete weir tank.

(4) Install concrete separator tank.

Note 1: All retaining walls to be reinforced with No. 4 bent vertical bars on 1-ft centers, and single No. 4 horizontal bars at the top and bottom.

Note 2: All top edges of retaining walls and curb to be provided with 3 x 3 x 1/4-in steel angle irons with anchors.

c. Storage Tanks for Water and Fuel - - - - - - - - $14,000

(1) Furnish and install one 10,000 gal steel water tank, reinforced concrete dike.

(2) Furnish and install one 3,000 gal steel fuel tank.

Work includes necessary excavation for underground installation, sand bed, reinforced concrete top slab, and miscellaneous tank piping.

d. Control Building - - - - - - - - - - - - - - - - - - - $ 7,000

(1) Erect control building 7 x 8 x 8 ft high located approximately 75 ft from fire area.

(2) Floor on control building to be elevated 10 ft above fire area.

(3) Building to be constructed of lightweight steel members, with insulated metal wall panels, metal roof deck, steel floor plate, service door, tempered glass observation window, steel ship's ladder, and concrete footings for posts.

e. Electrical Work - $ 3,200

(1) Provide electrical trenching.

(2) Install conduits and wiring for pump hook-ups.

(3) Install wiring and lighting in control building.

f. Plumbing Work - $ 3,800

(1) Do necessary trenching and sand filling.

(2) Furnish and install piping for water system.

(3) Furnish and install piping for fuel system.

g. Purchase Costs of Major Components - - - - - - - $ 8,000

(1) Pumps and motors for fuel ($4,000).

(2) Control valves and fuel meter ($3,100).

(3) Miscellaneous valves, strainers, pressure gages, spray nozzles ($900).

h. Preparation of detail drawings and specifications by base civil engineers. $ 000

Total Estimated Cost $49,000

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